Claims

1. A mass spectrometer comprising:

an ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use; and

a time of flight mass analyser.

2. A mass spectrometer as claimed in claim 1, wherein said electrodes are connected to an AC or RF voltage supply.

3. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap accumulates and periodically releases ions without substantially fragmenting ions.

4. A mass spectrometer as claimed in claim 2, wherein an axial DC voltage gradient is maintained in use along at least a portion of the length of the ion trap.

5. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap comprises a plurality of segments, each segment comprising a plurality of electrodes having apertures through which ions are transmitted and wherein all the electrodes in a segment are maintained at substantially the same DC potential and wherein adjacent electrodes in a segment are supplied with different phases of an AC or RF voltage.

6. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap is selected from the group consisting of: (i) 10-20 electrodes; (ii) 20-30 electrodes; (iii) 30-40 electrodes; (iv) 40-50 electrodes; (v) 50-60 electrodes; (vi) 60-70 electrodes; (vii) 70-80 electrodes; (viii) 80-90 electrodes; (ix) 90-100 electrodes; (x) 100-110 electrodes; (xi) 110-120

electrodes; (xii) 120-130 electrodes; (xiii) 130-140 electrodes; (xiv) 140-150 electrodes; (xv) > 150 electrodes; (xvi) ≥ 5 electrodes; and (xvii) ≥ 10 electrodes.

7. A mass spectrometer as claimed in claim 1, wherein the diameter of the apertures of at least 50% of the electrodes forming said ion tunnel ion trap is selected from the group consisting of: (i) ≤ 10 mm; (ii) ≤ 9 mm; (iii) ≤ 8 mm; (iv) ≤ 7 mm; (v) ≤ 6 mm; (vi) ≤ 5 mm; (vii) ≤ 4 mm; (viii) ≤ 3 mm; (ix) ≤ 2 mm; and (x) ≤ 1 mm.

8. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap is maintained, in use, at a pressure selected from the group consisting of: (i) > 1.0×10^{-3} mbar; (ii) > 5.0×10^{-3} mbar; (iii) > 1.0×10^{-2} mbar; (iv) 10^{-3}-10^{-2} mbar; and (v) 10^{-4}-10^{-1} mbar.

9. A mass spectrometer as claimed in claim 1, wherein at least 50%, 60%, 70%, 80%, 90% or 95% of the electrodes forming the ion tunnel ion trap have apertures which are substantially the same size or area.

10. A mass spectrometer as claimed in claim 1, wherein the thickness of at least 50% of the electrodes forming said ion tunnel ion trap is selected from the group consisting of: (i) ≤ 3 mm; (ii) ≤ 2.5 mm; (iii) ≤ 2.0 mm; (iv) ≤ 1.5 mm; (v) ≤ 1.0 mm; and (vi) ≤ 0.5 mm.

11. A mass spectrometer as claimed in claim 1, further comprising a continuous or pulsed ion source.

12. A mass spectrometer as claimed in claim 1, further comprising an ion source selected from the group consisting of: (i) Electrospray ("ESI") ion source; (ii) Atmospheric Pressure Chemical Ionisation ("APCI") ion

source; (iii) Atmospheric Pressure Photo Ionisation ("APPI") ion source; (iv) Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source; (v) Laser Desorption Ionisation ion source; (vi) Inductively Coupled Plasma ("ICP") ion source; (vii) Electron Impact ("EI) ion source; and (viii) Chemical Ionisation ("CI") ion source.

13. A mass spectrometer as claimed in claim 1, wherein at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 95% of said electrodes are connected to both a DC and an AC or RF voltage supply.

14. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap has a length selected from the group consisting of: (i) < 5 cm; (ii) 5-10 cm; (iii) 10-15 cm; (iv) 15-20 cm; (v) 20-25 cm; (vi) 25-30 cm; and (vii) > 30 cm.

15. A mass spectrometer as claimed in claim 1, wherein an axial DC voltage difference maintained along a portion of the ion tunnel ion trap is selected from the group consisting of: (i) 0.1-0.5 V; (ii) 0.5-1.0 V; (iii) 1.0-1.5 V; (iv) 1.5-2.0 V; (v) 2.0-2.5 V; (vi) 2.5-3.0 V; (vii) 3.0-3.5 V; (viii) 3.5-4.0 V; (ix) 4.0-4.5 V; (x) 4.5-5.0 V; (xi) 5.0-5.5 V; (xii) 5.5-6.0 V; (xiii) 6.0-6.5 V; (xiv) 6.5-7.0 V; (xv) 7.0-7.5 V; (xvi) 7.5-8.0 V; (xvii) 8.0-8.5 V; (xviii) 8.5-9.0 V; (xix) 9.0-9.5 V; (xx) 9.5-10.0 V; and (xxi) > 10V.

16. A mass spectrometer as claimed in claim 1, wherein an axial DC voltage gradient is maintained along at least a portion of ion tunnel ion trap selected from the group consisting of: (i) 0.01-0.05 V/cm; (ii) 0.05-0.10 V/cm; (iii) 0.10-0.15 V/cm; (iv) 0.15-0.20 V/cm; (v) 0.20-0.25 V/cm; (vi) 0.25-0.30 V/cm; (vii) 0.30-0.35

V/cm; (viii) 0.35-0.40 V/cm; (ix) 0.40-0.45 V/cm; (x) 0.45-0.50 V/cm; (xi) 0.50-0.60 V/cm; (xii) 0.60-0.70 V/cm; (xiii) 0.70-0.80 V/cm; (xiv) 0.80-0.90 V/cm; (xv) 0.90-1.0 V/cm; (xvi) 1.0-1.5 V/cm; (xvii) 1.5-2.0 V/cm; (xviii) 2.0-2.5 V/cm; (xix) 2.5-3.0 V/cm; and (xx) > 3.0 V/cm.

17. A mass spectrometer as claimed in claim 1, wherein said electrodes comprise ring, annular, plate or substantially closed loop electrodes.

18. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap comprises an entrance and/or exit electrode for trapping ions within said ion tunnel ion trap.

19. A mass spectrometer as claimed in claim 1, further comprising means for introducing a gas into said ion tunnel ion trap for collisional cooling without fragmentation of ions.

20. A mass spectrometer as claimed in claim 1, wherein said ion tunnel ion trap has an ion confinement volume selected from the group consisting of: (i) $\geq$ 20 mm^3; (ii) $\geq$ 50 mm^3; (iii) $\geq$ 100 mm^3; (iv) $\geq$ 200 mm^3; (v) $\geq$ 500 mm^3; (vi) $\geq$ 1000 mm^3; (vii) $\geq$ 1500 mm^3; (viii) $\geq$ 2000 mm^3; (ix) $\geq$ 2500 mm^3; (x) $\geq$ 3000 mm^3; and (xi) $\geq$ 3500 mm^3.

21. A mass spectrometer as claimed in claim 1, wherein said time of flight analyser comprises a pusher and/or puller electrode for ejecting packets of ions into a substantially field free or drift region wherein ions contained in a packet of ions are temporally separated according to their mass to charge ratio, wherein ions are arranged to be released from said ion tunnel ion trap at a predetermined time before or at substantially

the same time that said pusher and/or puller electrode ejects a packet of ions into said field free or drift region.

22. A mass spectrometer comprising:

an ion tunnel ion trap comprising ≥ 10 ring or plate electrodes having substantially similar internal apertures between 2-10 mm in diameter and wherein a DC potential gradient is maintained, in use, along a portion of the ion tunnel ion trap and two or more axial potential wells are formed along the length of the ion trap.

23. A mass spectrometer comprising:

an ion tunnel ion trap comprising at least three segments, each segment comprising at least four electrodes having substantially similar sized apertures through which ions are transmitted in use;

wherein in a mode of operation:

electrodes in a first segment are maintained at substantially the same first DC potential but adjacent electrodes are supplied with different phases of an AC or RF voltage supply;

electrodes in a second segment are maintained at substantially the same second DC potential but adjacent electrodes are supplied with different phases of an AC or RF voltage supply;

electrodes in a third segment are maintained at substantially the same third DC potential but adjacent electrodes are supplied with different phases of an AC or RF voltage supply;

wherein said first, second and third DC potentials are all different.

24. A mass spectrometer comprising:

an ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use, wherein the transit time of ions through the ion tunnel ion trap is selected from the group consisting of: (i) ≤ 0.5 ms; (ii) ≤ 1.0 ms; (iii) ≤ 5 ms; (iv) ≤ 10 ms; (v) ≤ 20 ms; (vi) 0.01-0.5 ms; (vii) 0.5-1 ms; (viii) 1-5 ms; (ix) 5-10 ms; and (x) 10-20 ms.

25. A mass spectrometer comprising:

an ion tunnel ion trap, said ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use, and wherein in a mode of operation trapping DC voltages are supplied to some of said electrodes so that ions are confined in two or more axial DC potential wells.

26. A mass spectrometer comprising:

an ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use, and wherein in a mode of operation a V-shaped, W-shaped, U-shaped, sinusoidal, curved, stepped or linear axial DC potential profile is maintained along at least a portion of said ion tunnel ion trap.

27. A mass spectrometer comprising:

an ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use, and wherein in a mode of operation an upstream portion of the ion tunnel ion trap continues to receive ions into the ion tunnel ion trap whilst a downstream portion of the ion tunnel ion trap separated from the upstream portion by a potential barrier stores and periodically releases ions.

28. A mass spectrometer as claimed in claim 27, wherein said upstream portion of the ion tunnel ion trap has a length which is at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of the total length of the ion tunnel ion trap.

29. A mass spectrometer as claimed in claim 27, wherein said downstream portion of the ion tunnel ion trap has a length which is less than or equal to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of the total length of the ion tunnel ion trap.

30. A mass spectrometer as claimed in claim 27, wherein the downstream portion of the ion tunnel ion trap is shorter than the upstream portion of the ion tunnel ion trap.

31. A mass spectrometer as claimed in claim 27, wherein ions are substantially not fragmented within said ion tunnel ion trap.

32. A mass spectrometer comprising:

a continuous ion source for emitting a beam of ions;

an ion trap arranged downstream of said ion source, said ion trap comprising ≥ 5 electrodes having apertures through which ions are transmitted in use, wherein said electrodes are arranged to radially confine ions within said apertures, and wherein ions are accumulated and periodically released from said ion trap without substantial fragmentation of said ions; and

a discontinuous mass analyser arranged to receive ions released from said ion trap.

33. A mass spectrometer as claimed in claim 32, wherein an axial DC voltage gradient is maintained along at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90% or 95% of the length of said ion trap.

34. A mass spectrometer as claimed in claim 32, wherein said continuous ion source comprises an Electrospray or Atmospheric Pressure Chemical Ionisation ion source.

35. A mass spectrometer as claimed in claim 32, wherein said discontinuous mass analyser comprises a time of flight mass analyser.

36. A method of mass spectrometry, comprising:

trapping ions in an ion tunnel ion trap comprising a plurality of electrodes having apertures through which ions are transmitted in use; and

releasing ions from said ion tunnel ion trap to a time of flight mass analyser.

37. A method as claimed in claim 36, further comprising maintaining an axial DC voltage gradient along at least a portion of the length of the ion trap.